EVGUENI (JENIA) TEVELEV

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Employment

- Professor, University of Massachusetts in Amherst, 2016–current
- Associate Professor, University of Massachusetts in Amherst, 2010–2016
- Assistant Professor, University of Massachusetts in Amherst, 2006–2010
- Instructor (postdoc), University of Texas in Austin, 2002–2006

Awards

- Fulbright Scholarship, 2019
- Simons Fellowship, 2019
- Sloan Fellowship, 2007

Personal grants from the National Science Foundation

- DMS-2101726, *New Frontiers of Algebraic Geometry*, 2021–2024
- DMS-1701704. *Moduli Spaces: New Directions*, 2017–2021
- DMS-1303415. *Moduli Spaces of Curves and Surfaces*, 2013–2017 (and REU 1539510)
- DMS-1001344. *Geometry of Moduli of Curves and Surfaces*, 2010–2013
- DMS-0701191. *Geometry of Compact Moduli Spaces*, 2007–2010 (and REU 0827994)

Conference grants from the National Science Foundation

- DMS-1937705, 1360543, 1064426, 0963853. *Algebraic Geometry NorthEastern Series*
- DMS-1935081, *Latin American School of Algebraic Geometry and Applications*

Visiting research positions (with external funding)

- Fulbright Professor, Universidad Católica de Chile, Fall 2019–Spring 2020
- Visiting Professor, Fields Institute, Toronto, Canada, Fall 2016
- Member, Mathematical Sciences Research Institute, Berkeley, CA, Fall 2009
- Member, Institut des Hautes Études Scientifiques, France, Summer 2007
- Postdoctoral research fellow, University of Basel, Switzerland, 2000–2001

Other affiliations

- Editor, Transformation Groups (Springer Nature, Switzerland)

Education

- Moscow State University (Russia), PhD in Mathematics, 2000
- Moscow State University (Russia), Diploma with Honors in Mathematics, 1995

Postdocs mentored at UMass

- Luca Schaffler (currently at KTH, Stockholm, Sweden), 2017–2020
- Giancarlo Urzua, (Universidad Catolica de Chile, Santiago, Chile), 2008–2011
- Ana-Maria Castravet, (Université de Versailles, France), 2006 – 2007

Languages: English, Russian, Spanish

Graduate students

- Arie Stern
- Sebastian Torres (currently at University of Miami)
- Tassos Vogiannou (Electronic Arts)
- Julie Rana (Lawrence University) received Distinguished Thesis Award

Undergraduate students

- Elizabeth Pratt
- Shelby Cox (placed at the PhD program at University of Michigan), received UMass Rising Researcher award, NSF Graduate Research Fellowship
- Greg McGrath (UC Santa Barbara)
- Stephen Obinna (Brown University)
- Morgan Opie (Harvard) received Alice T. Schafer Prize runner-up, a national prize for excellence in mathematics by an undergraduate woman, UMass Rising Researcher award, Churchill scholarship for postgraduate study at Cambridge, NSF Graduate Research Fellowship
- Nicolas Reyes (UT Austin), received NSF Graduate Research Fellowship
- Nate Harman (MIT), received NSF Graduate Research Fellowship
- Charles Boyd (Internship at Macaulay 2)
- Ilya Scheidwasser (Northeastern)
- Alex Levine (University of Vermont)

Selected publications

- *BGMN conjecture via stable pairs*, with Sebastian Torres, 41p. (2021), arXiv:2108.11951
  Abstract. Let C be a smooth projective curve of genus $g > 1$ and let N be the moduli space of stable rank 2 vector bundles on C of odd degree. We construct a semi-orthogonal decomposition of the bounded derived category of N conjectured by Narasimhan and by Belmans, Galkin and Mukhopadhyay. It has two blocks for each i-th symmetric power of C for $i = 0, ..., g-2$ and one block for the $(g-1)$-st symmetric power. We conjecture that the subcategory generated by our blocks has a trivial semi-orthogonal complement, proving the full BGMN conjecture. Our proof is based on an analysis of wall-crossing between moduli spaces of stable pairs, combining classical vector bundles techniques with the method of windows into derived categories.

- *Blown-up toric surfaces with non-polyhedral effective cone*, with Ana-Maria Castravet, Antonio Laface and Luca Ugaglia, 55 p. (2020), arXiv:2009.14298
  Abstract. We construct examples of projective toric surfaces whose blow-up at a general point has a non-polyhedral pseudo-effective cone, both in characteristic 0 and in every prime characteristic p. As a consequence, we prove that the pseudo-effective cone of the Grothendieck–Knudsen moduli space of stable rational curves with n marked points is not polyhedral for $n \geq 10$ in characteristic 0 and in characteristic p, for all primes p. Many of these toric surfaces are related to a very interesting class of arithmetic threefolds that we call arithmetic elliptic pairs of infinite order. Their analysis in characteristic p relies on tools of arithmetic geometry and Galois representations in the spirit of the Lang-Trotter conjecture, producing toric surfaces whose blow-up at a general point has a non-polyhedral pseudo-effective cone in characteristic 0 and in characteristic p, for an infinite set of primes p of positive density.

- *Scattering amplitudes of stable curves*, 51 p. (2020), arXiv:2007.03831
  Abstract. Equations of hypertree divisors on the Grothendieck-Knudsen moduli space of stable rational curves, introduced by Castravet and Tevelev, appear as numerators of scattering amplitude forms for n massless particles in $N = 4$

Yang-Mills theory in the work of Arkani-Hamed, Bourjaily, Cachazo, Postnikov and Trnka. Rather than being a coincidence, this is just the tip of the iceberg of an exciting relation between algebraic geometry and high energy physics. We interpret scattering amplitude forms as probabilistic Brill-Noether theory: the study of statistics of images of n marked points under a random meromorphic function uniformly distributed with respect to the translation-invariant volume form of the Jacobian. We focus on the maximum helicity violating regime, which leads to a beautiful physics-inspired geometry for various classes of algebraic curves: smooth, stable, hyperelliptic, real algebraic, etc.

- *Derived category of moduli of pointed curves – II*, with Ana-Maria Castravet, 59 p. (2020), arXiv:2002.02889
  Abstract. We prove the Manin-Orlov conjecture: the moduli space of stable rational curves with n marked points has a full exceptional collection equivariant under the action of the symmetric group S_n permuting the marked points. In particular, its K-group with integer coefficients is a permutation S_n-lattice.

- *Compactifications of moduli spaces of points and lines in* $\mathbb{P}^2$, with Luca Schaffler, International Math. Research Notices (2021), 79p.
  Abstract. Projective duality identifies moduli spaces of points in $\mathbb{P}^2$ and lines in the dual $\mathbb{P}^2$. The latter space admits Kapranov's Chow quotient compactification, studied also by Lafforgue, Hacking, Keel, Tevelev, and Alexeev, which gives an example of a KSBA moduli space of stable surfaces: it carries a family of reducible degenerations of $\mathbb{P}^2$ with n "broken lines". Gerritzen and Piwek proposed a dual perspective, a compact moduli space parametrizing reducible degenerations of $\mathbb{P}^2$ with n smooth points. We investigate the relation between these approaches, answering a question of Kapranov from 2003.

- *Spherical Tropicalization*, with Tassos Vogiannou, Transformation Groups **26** (2021), 691–718 (Ernest Vinberg memorial volume)
  Abstract. We extend tropicalization and tropical compactification of subvarieties of algebraic tori to subvarieties of spherical homogeneous spaces. Given a tropical compactification of a subvariety, we show that the support of the colored fan of the ambient spherical variety agrees with the tropicalization of the subvariety. The proof is based on our equivariant version of the attening by blow-up theorem. We provide many examples.

- *Exceptional collections on certain Hassett spaces*, with Ana-Maria Castravet, Épijournal de Géométrie Algébrique, **4** (2020), 1-34
  Abstract. We construct an $S_2 \times S_n$ invariant full exceptional collection on Hassett spaces of weighted stable rational curves with $n+2$ markings and weights $(\frac{1}{2}+a, \frac{1}{2}+a, b, ..., b)$, for very small positive a, b, that can be identified with symmetric GIT quotients of $(\mathbb{P}^1)^n$ by the diagonal action of $\mathbb{G}_m$ when n is odd, and their Kirwan desingularization when n is even. The existence of such an exceptional collection is one of the needed ingredients in order to prove the existence of a full S_n-invariant exceptional collection on the moduli space of stable rational curves with n marked points. To prove exceptionality we use the method of windows in derived categories. To prove fullness we use previous work on the existence of invariant full exceptional collections on Losev-Manin spaces.

- *Derived category of moduli of pointed curves – I*, with Ana-Maria Castravet, Algebraic Geometry **7** (6) (2020), 722–757
  Abstract. This is the first paper in the sequence devoted to derived category of moduli spaces of curves of genus 0 with marked points. We develop several approaches to describe it equivariantly with respect to the action of the symmetric

group permuting marked points. We construct an equivariant full exceptional collection on the Losev-Manin space which categorifies derangements.

- *The Craighero-Gattazzo surface is simply-connected*, with Julie Rana and Giancarlo Urzua, Compositio, **153** (2017), 557–585
  Abstract. We show that the Craighero-Gattazzo surface, the minimal resolution of an explicit complex quintic surface with four elliptic singularities, is simply-connected. This was conjectured by Dolgachev and Werner, who proved that its fundamental group has a trivial profinite completion. The Craighero-Gattazzo surface is the only explicit example of a smooth simply-connected complex surface of geometric genus zero with ample canonical class. We hope that our method will find other applications: to prove a topological fact about a complex surface we use an algebraic reduction mod p technique and deformation theory.

- *Flipping Surfaces*, with Paul Hacking and Giancarlo Urzua, Journal of Algebraic Geometry, **26** (2017), 279–345
  Abstract. We study semistable extremal threefold neighborhoods following the earlier work of Mori, Kollar, and Prokhorov. We classify possible flips and extend Mori's algorithm for computing flips of extremal neighborhoods of type k2A to more general neighborhoods of type k1A. In fact we show that they belong to the same deformation family as k2A, and we explicitly construct the universal family of extremal neighborhoods. This construction follows very closely Mori's division algorithm, which we interpret as a sequence of mutations in the cluster algebra of rank 2 with general coefficients. We identify, in the versal deformation space of a cyclic quotient singularity, the locus of deformations such that the total space admits a (terminal) antiflip. We show that these deformations come from at most two irreducible components of the versal deformation space. As an application, we give an algorithm for computing stable one-parameter degenerations of smooth projective surfaces (under some conditions) and describe several components of the Kollar-Shepherd-Barron boundary of the moduli space of smooth canonically polarized surfaces of geometric genus zero.

- $\overline{M}_{0,n}$ *is not a Mori Dream Space*, with Ana-Maria Castravet, Duke Math. Journal, **164**, no. 8 (2015), 1641–1667
  Abstract. Building on the work of Goto, Nishida and Watanabe on symbolic Rees algebras of monomial primes, we prove that the moduli space of stable rational curves with n punctures is not a Mori Dream Space for $n > 133$. This answers the question of Hu and Keel.

- *On a Question of Teissier*, Collectanea Math., 65, no. 1 (2014), 61–66
  Abstract. We answer positively a question of B. Teissier on the existence of a resolution of singularities inside an equivariant map of toric varieties.

- *Hypertrees, Projections, and Moduli of Stable Rational Curves*, with Ana-Maria Castravet, Crelle's Journal, **675** (2013), 121–180.
  Abstract. We give a description for the subcone of effective divisors of the Grothendieck-Knudsen moduli space of stable rational curves with n marked points. Namely, we introduce new combinatorial structures called hypertrees and show they give exceptional divisors with many remarkable properties.

- *Rigid Curves on* $\overline{M}_{0,n}$ *and Arithmetic Breaks* , with Ana-Maria Castravet, Contemporary Math., **564** (2012), 19–67
  Abstract. A result of Keel and McKernan states that a hypothetical counterexample to the F-conjecture must come from rigid curves on the moduli space of stable rational curves that intersect the interior. We exhibit several ways of constructing rigid curves. In all our examples, a reduction mod p argument shows

that the classes of the rigid curves that we construct can be decomposed as sums of F-curves.

- *Stable Pair, Tropical, and Log Canonical Compact Moduli of Del Pezzo Surfaces*, with Paul Hacking and Sean Keel, Inventiones Math. **178** , no.1 (2009), 173–228
  Abstract. We give a functorial normal crossing compactification of the moduli of smooth marked cubic surfaces entirely analogous to the Grothendieck-Knudsen moduli space of stable rational curves.

- *Equations for* $\overline{M}_{0,n}$, with Sean Keel, International J. of Math. **20**, no.9 (2009), 1–26
  Abstract. We show that the log canonical bundle of the moduli space of stable rational curves is very ample; show the homogeneous coordinate ring is Koszul; and give a nice set of rank 4 quadratic generators for the homogeneous ideal: the embedding is equivariant for the symmetric group, and the image lies on many Segre embedded copies of $\mathbb{P}^1 \times \mathbb{P}^2 \times \ldots \times \mathbb{P}^{n-3}$, permuted by the symmetric group. The homogeneous ideal of the moduli space is the sum of the homogeneous ideals of these Segre embeddings.

- *Elimination Theory for Tropical Varieties*, with Bernd Sturmfels, Math. Research Letters **15**, no.3 (2008), 543–562
  Abstract. Tropical algebraic geometry offers new tools for elimination theory and implicitization. We determine the tropicalization of the image of a subvariety of an algebraic torus under any homomorphism from that torus to another torus.

- *The Newton Polytope of the Implicit Equation*, with Bernd Sturmfels and Josephine Yu, Moscow Math. Journal **7**, no.2 (2007), 327–346
  Abstract. We apply tropical geometry to study the image of a map defined by Laurent polynomials with generic coefficients. If this image is a hypersurface then our approach gives a construction of its Newton polytope.

- *Compactifications of Subvarieties of Tori,* Amer. J. of Math. **129** (2007), 1087–1104
  Abstract. We study compactifications of subvarieties of algebraic tori defined by imposing a sufficiently fine polyhedral structure on their non-archimedean amoebas. These compactifications have many nice properties, for example any k boundary divisors intersect in codimension k. We consider some examples including the moduli space of stable rational curves (and more generally log canonical models of complements of hyperplane arrangements) and compact quotients of Grassmannians by a maximal torus.

- *Compactification of the Moduli Space of Hyperplane Arrangements*, with Paul Hacking and Sean Keel, Journal of Algebraic Geometry **15** (2006), 657–680
  Abstract. Consider the moduli space M_0 of arrangements of n hyperplanes in general position in projective $(r-1)$-space. When $r = 2$ the space has a compactification given by the moduli space of stable curves of genus 0 with n marked points. In higher dimensions, the analogue of the moduli space of stable curves is the moduli space of stable pairs (S, B) consisting of a variety S (possibly reducible) and a divisor $B = B_1 + ... + B_n$ satisfying various additional assumptions. We identify the closure of M_0 in the moduli space of stable pairs as Kapranov's Chow quotient compactification of M_0, and give an explicit description of the pairs at the boundary. We also construct additional irreducible components of the moduli space of stable pairs.

- *Hilbert's 14-th Problem and Cox Rings*, with Ana-Maria Castravet, Compositio **142** (2006), 1479–1498

  Abstract. Our main result is the description of generators of the total coordinate ring of the blow-up of $\mathbb{P}^n$ in any number of points that lie on a rational normal curve. As a corollary we show that the algebra of invariants of the action

of a two-dimensional vector group introduced by Nagata is finitely generated by certain explicit determinants. We also prove the finite generation of the algebras of invariants of actions of vector groups related to T-shaped Dynkin diagrams introduced by Mukai.

- *Geometry of Chow Quotients of Grassmannians*, with Sean Keel, Duke Math. Journal **134**, no. 2 (2006), 259–311
  Abstract. We consider Kapranov's Chow quotient compactification of the moduli space of ordered n-tuples of hyperplanes in $\mathbb{P}^{r-1}$ in linear general position. For $r = 2$ this is canonically identified with the Grothendieck-Knudsen moduli space of stable rational curves which has among others the nice properties 1) Modular meaning: stable pointed rational curves; 2) Canonical description of limits of one parameter degenerations; 3) Natural Mori-theoretic meaning: log canonical compactification. We prove (1-2) generalize naturally to all (r, n), but that (3), which we view as the deepest, fails except possibly in the cases $(3, 6)$,$(3, 7)$,$(3, 8)$, where we conjecture it holds.
- *Projective Duality and Homogeneous Spaces*, Springer 2005